Stabilization of Soil by Foundry Sand Waste

Manali D. Patel[1], Amitkumar R. Chauhan[2]

[1]*Laxmi Institute of Technology, Sarigam*
[2]*Head of Department, Dept. of Civil Engineering, Laxmi Institute of Technology, Sarigam, Gujarat*

---***---

Abstract - *Soil is the fundamental establishment of any respectful building structure. But at many different places soil is unable to take the load coming from the structure and the structure fails because of poor bearing capacity of soil. In such kind of cases the strength of the soil can be modified by using supplementary materials. In this work waste foundry sand is used as a supplementary unit to stabilize the soil sample collected from the SARIGAM area. The foundry sand waste may hamper nature around us if not discarded appropriately, so utilizing them in soil stabilization assists with keeping our condition clean. In this work the foundry sand waste is blended with soil to find out the relative quantity addition for better strength of soil. Standard proctor test is used to find out the best possible addition of foundry sand waste using the parameter like optimum water content and maximum dry density of the soil sample. The replacement level of foundry sand waste that has been utilized in this work comprises of 0%, 5%, 10%, 15% and 20% and their respective MDD and OMC is find out.*

Key Words*: *Bearing capacity, Stabilization, Standard proctor, Foundry sand waste

1. INTRODUCTION

In any respectful building structure the most significant job is played by its establishment and for the establishment to be solid the soil around it should be strong. Numerous places have appropriate soil for development however a few places don't have reasonable soil for development. To make weak soil appropriate for development, soil stabilization procedure should be adopted. Stabilization is the way toward mixing and blending materials in with the soil to improve certain properties of soil. The procedure may incorporate the mixing of soils to accomplish an ideal gradation or the blending of industrially accessible added substances that may modify the gradation, surface or plasticity or go about as a fastener for cementation of the soil. Soils are commonly settled to expand their quality and durability. sIn this work, soil adjustment has been finished with the use of waste foundry sand. By utilizing this waste material in soil stabilization one can decrease the issue of their removal and it also shows sign of improvement in soil base for establishment. In an effort to use the waste foundry sand in large volume, research is being carried out for its possible substantial utilization as partial replacement of fine aggregate in concrete. Also, foundries use high quality size-specific silica sands for use in their moulding and casting operations. Usually raw sand is of a higher quality than the typical bank run or natural sands used in fill construction sites. Therefore, this can be a very competent material for the compaction of soil also. Blending this waste with the soil can modify the various properties of the soil can be used to enhance the weak or collapsible soils.

1.1 Foundry Sand Waste

The disposed of material from the metal throwing industry which principally comprise of silica sand and polluting influence of ferrous and nonferrous side-effects from the metal throwing process itself and an assortment of folios is called foundry sand waste. It is utilized for the hundreds of years as an embellishment throwing material on account of its high warm conductivity. For different foundry activities, crude sand is utilized and a few fasteners and added substances are added into it to improve its properties. In light of cover framework utilized, foundry sand is grouped into two classifications for example earth reinforced (green) sand and artificially fortified sand. As obvious from the names, mud reinforced or green sand comprises of dirt as folio though in artificially fortified sand synthetic concoctions are utilized as fasteners. Green foundry sand is commonly made out of 85–95% silica sand, 4–10% of bentonite earth as cover then 2–10% of carbonaceous added substance, to improve completing of throwing surface. It additionally contains hints of oxides, for example, MgO, K2O, and TiO2. While, synthetically fortified sand or concoction foundry sand, comprises of 93–99% silica sand and around 1–3% compound cover.

Fig -1: Waste Foundry Sand

Table -1: Properties of waste Foundry Sand

Property	Results
Fineness modulus	1.60
Specific gravity	2.33
Bulk density	1250 kg/m3

1.2 Foundry Sand Physical Characteristics

1. Particle size and shape

Foundry sand is sub-angular to round in shape . Alike regular sand, WFS also mainly consists of silica but its silica content has been found lower than regular sand. Depending upon the industry sector from which it originates, type of casting process, type of additives used for moulding, number of times the sand is recycled and type and amount of binder used, its physical and chemical characteristics may vary. About 85–90% of its particles are smaller than 100 mm. It is principally made up of sand which is evident from the particle size (0.05–2 mm) of WFS, obtained from 39 foundries, ranging from 76.6% to 100%, with a median of 90.3%. Since it is basically fine aggregate so it can be expected to be used in many applications as substitute of natural sand. Fineness modulus of WFS has been found in the range of 0.9–1.8 compared to 2.3–3.1 for normal sand.

2. Chemical composition

Depending upon type of metal, type of binder and combustible used, the chemical composition of waste foundry sand may vary and it further influences its performance. Waste foundry sand is rich in silica content and is coated with thin film of burnt carbon, dust and residual binder such as bentonite, sea coal or chemicals or resins. Due to presence of silica content it is hydrophilic owing to which it attracts water to its surface. Generally, silica content of WFS is lower than regular sand because of the presence of additives. Waste foundry sands from different foundry processing stages exhibit different physical and chemical properties.. The waste foundry sand having more carbon content showed more water absorption (5.4%) than the other having lesser carbon content (3.3%).

Green sands are commonly dark or dim, not green. Artificially reinforced sand is regularly a medium tan or grayish shading.

3. Mechanical properties

Tests led on WFS to check its quality and sturdiness, for example, low Micro-Deval scraped area and magnesium sulfate sufficiency misfortune (ASTM C88-05) have demonstrated great outcomes, showing great solidness. Scraped area misfortune was found underneath 2% while; Magnesium sulfate adequacy misfortune was inside 5–15%. Javed and Lovell revealed generally high adequacy misfortune, which might be because of the examples of bound sand misfortune and not a breakdown of individual sand particles. The edge of shearing obstruction or inner rubbing edge of WFS has been discovered tantamount to shearing opposition of typical sands for example somewhere in the range of 33° and 40°.

1.3 Standard Proctor Test

Determining of optimum moisture content and maximum dry density the most commonly used test is proctor test. Compaction can be defined as to remove the voids from the soil. Also the rearrangement of the soil particles is done by the compaction process. This test is useful because it improves the mechanical property of the soil. In this test the soil is used with known water content and cylindrical mould with collar of standard dimension of height and diameter. The soil is compacted into mould at 25 equal numbers of blows from a standard weight of hammer. After that the process is repeated at different water content to determine the dry density of each sample taken. After that a graph is made between the dry density and moisture content. The maximum dry density is obtained from a peak point and its corresponding moisture content is taken as the optimum moisture content.

2. RESULTS

Specific gravity

Soil sample	2.40
Foundry sand waste	2.55

Normal moisture content

Soil sample	12.65%
Foundry sand waste	1.27%

Limit test of soil

Plastic limit	21.65
Liquid limit	33.5

Fig -2: compacted soil in mould

Table -2: Observations of Standard Proctor Test on Normal Soil

Sr. No.	Bulk density (g/cc)	Dry density (g/cc)	Water content (%)
1	1.43	1.37	4%
2	1.49	1.40	6%
3	1.56	1.44	8%
4	1.63	1.48	10%
5	1.73	1.54	12%
6	1.75	1.53	14%
7	1.78	1.52	16%

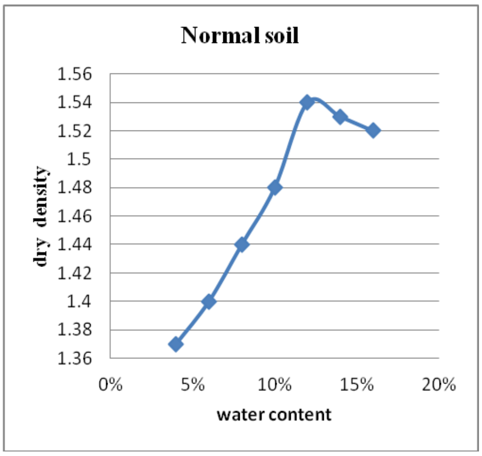

Chart -1: Dry Density of Normal Soil

Maximum Dry Density: 1.54 g/cc

Optimum Moisture Content: 12%

Table -3: Observations of Standard Proctor Test on Soil with 10% WFS

Sr. No.	Bulk density (g/cc)	Dry density (g/cc)	Water content (%)
1	1.54	1.48	4%
2	1.59	1.50	6%
3	1.65	1.52	8%
4	1.73	1.57	10%
5	1.80	1.61	12%
6	1.83	1.60	14%
7	1.85	1.59	16%

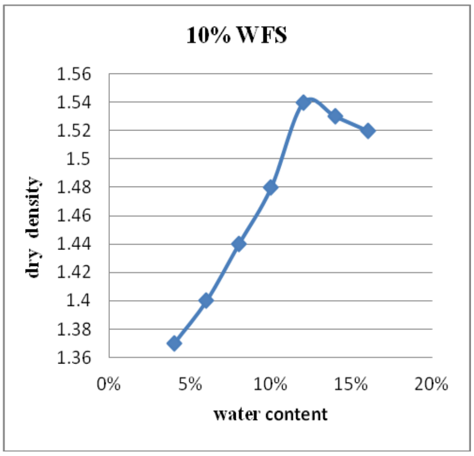

Chart -2: Dry Density of Soil with 10% WFS

Maximum Dry Density: 1.61 g/cc

Optimum Moisture Content: 12%

Table -4: Observations of Standard Proctor Test on Soil with 15% WFS

Sr. No.	Bulk density (g/cc)	Dry density (g/cc)	Water content (%)
1	1.62	1.56	4%
2	1.65	1.57	6%
3	1.72	1.59	8%
4	1.81	1.64	10%
5	1.92	1.71	12%
6	1.97	1.73	14%
7	1.99	1.71	16%

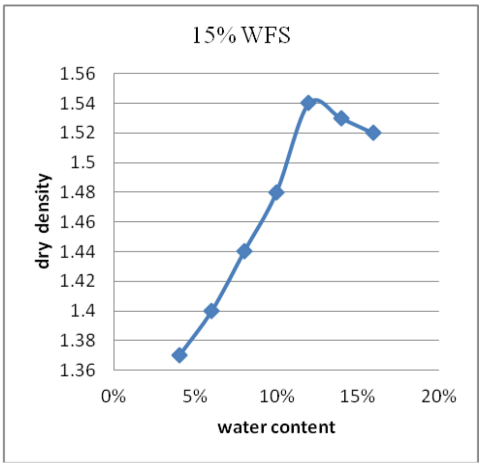

Chart -3: Dry Density of Soil with 15% WFS

Maximum Dry Density: 1.73 g/cc
Optimum Moisture Content: 14%

Table -5: Observations of Standard Proctor Test on Soil with 20% WFS

Sr. No.	Bulk density (g/cc)	Dry density (g/cc)	Water content
1	1.73	1.66	4%
2	1.76	1.67	6%
3	1.82	1.68	8%
4	1.86	1.69	10%
5	2.06	1.81	12%
6	2.16	1.89	14%
7	2.19	1.87	16%

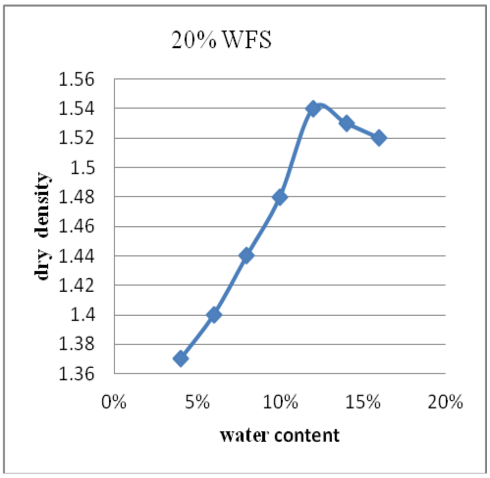

Chart -4: Dry Density of Soil with 20% WFS

Maximum Dry Density: 1.89 g/cc
Optimum Moisture Content: 14

Table -5: Comparison of Dry Density Curve with Different Percentage of Additives

Sr. No.	% of Foundry sand waste	MDD	OMC %
1	0	1.54	12
2	10	1.61	12
3	15	1.73	14
4	20	1.89	14

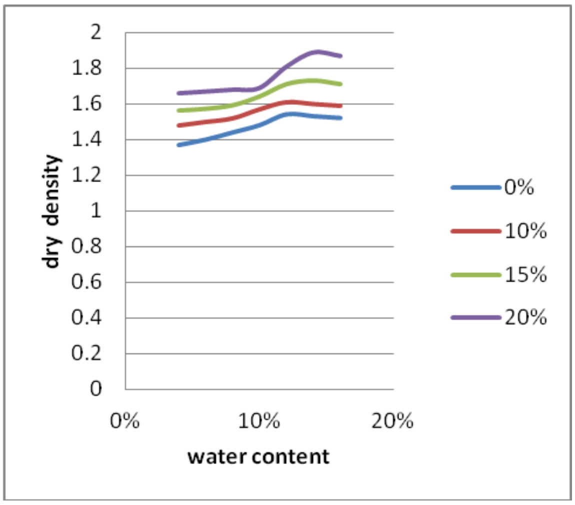

Chart -5: Comparison of Dry Density Curve with Different Percentage of Foundry Sand Waste

3. CONCLUSIONS

The present study shows the effect of stabilizing the soil with foundry sand waste at different water content. The results obtained from standard proctor test and based on maximum dry density and optimum moisture content obtained the following points can be concluded:

1. Addition of 0% of foundry sand waste gave 1.54 g/cc of MDD.
2. Addition of 10% of foundry sand waste gave 1.61 g/cc of MDD.
3. Addition of 15% of foundry sand waste gave 1.73 g/cc of MDD.
4. Addition of 20% of foundry sand waste gave 1.89 g/cc of MDD.

REFERENCES

[1] D.A.R. Dolage, M.G.S. Dias, C.T. Ariyawansa, Offshore sand as a fine aggregate for concrete, Production 3 (2013) 813–825.
[2] E.S. Winkler, A.A. Bol'shakov, Characterization of Foundry Sand Waste, Chelsea, Massachusetts, 2000.
[3] R. Siddique, G. De Schutter, A. Noumowe, Effect of used-foundry sand on the mechanical properties of concrete, Constr. Build. Mater. 23 (2009) 976–980, http://dx.doi.org/10.1016/j.conbuildmat.2008.05.005.
[4] S.P. Oudhia, An Overview of Indian Foundry Industry, Metalworld. (2015) 3–4.
[5] R. Siddique, G. Singh, Utilization of waste foundry sand (WFS) in concrete manufacturing, Resour. Conserv. Recycl. 55 (2011) 885–892, http://dx.doi.org/ 10.1016/j.resconrec.2011.05.001.
[6] R. Siddique, A. Noumowe, Utilization of spent foundry sand in controlled low- strength materials and concrete, Resour. Conserv. Recycl. 53 (2008) 27–35, http://dx.doi.org/10.1016/j.resconrec.2008.09.007.
[7] G. Kaur, R. Siddique, A. Rajor, Influence of fungus on properties of concrete made with waste foundry sand, J. Mater. Civil Eng. 25 (2013)484490,http://dx.doi.org/10.1061/(ASCE)MT.1943-5533.0000521.
[8] T.R. Naik, Foundry industry by-products utilization, (1989).
[9] E.A. Dayton, S.D. Whitacre, R.S. Dungan, N.T. Basta, Characterization of physical and chemical properties of spent foundry sands pertinent to beneficial use in manufactured soils, Plant Soil 329 (2010) 27–33, http://dx.doi.org/10.1007/ s11104-009-0120-0.
[10] J.M. Khatib, D.J. Ellis, Mechanical properties of concrete containing foundry sand, ACI Spec. Publ. 200 (2001) 733–748, http://dx.doi.org/10.14359/10612.
[11] R. Siddique, Y. Aggarwal, P. Aggarwal, E.H. Kadri, R. Bennacer, Strength, durability, and micro-structural properties of concrete made with, Constr. Build. Mater. 25 (2011) 1916–1925, http://dx.doi.org/10.1016/j.conbuildmat.2010.11.065.
[12] Y. Aggarwal, R. Siddique, Microstructure and properties of concrete using bottom ash and waste foundry sand as partial replacement of fine aggregates, Constr. Build. Mater. 54 (2014) 210–223, http://dx.doi.org/10.1016/j.conbuildmat.2013.12.051.
[13] F.A. Olutoge, S.O.A. Olawale, M.A. Gbadamosi, Strength behavior of concrete produced with foundry sand as fine aggregate replacement, Int. J. Emerg . Technol. Adv. Eng. 5 (2015) 35–38.
[14] T.R. Naik, R.N. Kraus, B.W. Ramme, F. Canpolat, Effects of fly ash and foundry sand on performance of architectural precast concrete, J. Mater. Civil Eng. 24 (2012)851-859 http://dx.doi.org/10.1061/(ASCE)MT.194355-33.0000432.
[15] J.M. Khatib, S. Baig, A. Bougara, C. Booth, Foundry Sand Utilization in Concrete Production, in: J. Zachar, P. Claisse, T.R. Naik, E. Ganjian (Eds.), Second International Conference on Sustainable Construction Materials and Technologies, 2010: p. 8. doi:ISBN 978-1-4507-1490-7.
[16] G.G. Prabhu, J.W. Bang, B.J. Lee, J.H. Hyun, Y.Y. Kim, Mechanical and durability properties of concrete made with used foundry sand as fine aggregate, Adv. Mater. Sci. Eng. (2015) 1–11, http://dx.doi.org/10.1155/2015/161753
[17] S. Javed, C.W. Lovell, L.E. Wood, Waste Foundry Sand in Asphalt Concrete, Transp. Res. Rec. 1437. (n.d.) 27–34.
[18] T.R. Naik, S.S. Singh, B.W. Ramme, Performance and leaching assessment of flowable slurry, J. Environ. Eng. 127 (2001) 359–368.
[19] Y. Guney, Y.D. Sari, M. Yalcin, A. Tuncan, S. Donmez, Re-usage of waste foundry sand in high-strength concrete, Waste Manage. 30 (2010)17051713,
[20] IS: 2720-1, 1983 Methods of test for soils, Preparation of dry soil samples for various tests.
[21] IS: 2720-2, 1973 Methods of test for soils, Determination of water content.
[22] IS: 2720-3, 1980 Methods of test for soils, Determination of specific gravity.
[23] IS: 2720-4, 1985 Methods of test for soils, Grain size analysis.
[24] IS: 2720-5, 1985 Methods of test for soils, Determination of liquid and plastic limit.
[25] IS: 2720-7, 1980 Methods of test for soils, Determination of water content dry density relation using light compaction.

BIOGRAPHIES

Manali D. Patel is a student of Civil Engineering Department, Laxmi Institute of Technology, Sarigam. Her research areas are Soil Stabilization.

Amitkumar R. Chauhan is Head of Civil Engineering Department, Laxmi Institute of Technology, Sarigam. He completed his ME in Water Resource Management from Government Engineering college Surat. His research areas are Flood Modelling, Watershed Management, Soil stabilization and Concrete Technology.